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A STUDY OF THE SPONTANEOUS ACTIVITY OF THE GUINEA PIG

DISSERTATION

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INTRODUCTION

For many years physiologists have been trying to obtain an objective test for fatigue in human beings. The problem presents many difficulties. The principle complications are due to the unusually sensitive emotional response mechanism which exists in man. Even when relatively simple tests of physiological work have been attempted, sympathetic inhibitory and stimulating mechanisms have made the interpretation of the results difficult.

In the past decade various investigators have turned to a study of spontaneous activity and fatigue in lower mammals in the hope of throwing some light on the fundamental problem of the relation between activity, rest and fatigue in these animals. The following paper deals with a study of this problem in the case of the guinea pig.

It is generally believed among laboratory workers that guinea pigs are very quiet animals. They will sit quietly in a corner of the cage for many hours when anyone is near them. This inactivity is apparently due to an inhibition from fear. If guinea pigs are placed in a quiet environment under normal conditions of temperature, humidity, and illumination they exhibit an hyper-activity which, so far as is known, is unique among mammals. By means of activity-recording cages, continuous records extending over several months have been obtained, which show the activity of the guinea pig to be organized on an entirely different plan from that of other rodents such as rats and mice.

Periodic alternations of complete rest and activity are conspicuously absent. Continuous and intermittent activity periods are present in the records but there are no indications of protracted intervals of sleep, which are familiar phenomena with rats and mice. There is likewise an absence of diurnal and nocturnal rhythm.

Studies have been made of the influence of changed environmental conditions and the relation of forced activity to food and rest.

The activity of the guinea pig and the rat has also been compared under identical conditions. The details of these experiments with typical illustrations are contained in the body of this paper.

REVIEW OF THE LITERATURE

In reviewing the literature I find that very little work has been done on the study of the normal amount of activity and quiet of animals in their natural environment. From the life study of various animals statements are made based upon casual observation but very little actual experimental work has been done under controlled conditions.

In using the term "quiet" I do not necessarily mean sleep. With most of the invertebrates and some of the vertebrates it is difficult to determine whether an animal sleeps or not. Authors also differ as to the interpretation of the word "sleep". Quiet, as here used, simply means a period of immobility.

Starting with the lowest form of animal life, the amoeba, Giblis (1908) found that this small animal showed definite periods of activity and quiet. These periods alternated during the twenty-four hours and their degree and duration depended upon the nature and abundance of food.

Hodge and Ackins (1895) studied the daily life of the protozoan Vorticella and found it showed no quiet periods at all but was continuously active.

It is difficult to determine the amount of activity and quiet among the lower forms of invertebrates because of their size and habit of life. This is especially true of aquatic forms. Slight movements of

the water may be mistaken for activity on the part of the organism. Among the molluscs, Szymanski (1920) found that in September the large-shelled snail (Helix pomatia) spent ten hours out of the twenty-four in activity and fourteen in quiet.

Pieron (1913) made some careful observations on the shrimp, crab and lobster and found that periods of immobility were frequent. The crab, he states, would remain quiet for a considerable length of time especially during the day.

The crawfish (Astacus fluviatilis) according to Szymanski (l.c.) has 7.5 hours of activity and 16.5 hours of quiet with rather long periods of each. The quiet periods occur chiefly during the night.

Pieron (l.c.) found that the states of activity and quiet among the insects were more like those of the higher vertebrates. Most of the diurnal insects remain quiet during the hours of night and are active throughout the day. Arnold Pictet (1904) made similar observations upon butterflies. They remain quiet from 5 or 6 o'clock in the evening until 9 or 10 the next morning. The nocturnal varieties remain quiet for 16 hours out of the twenty-four.

Szymanski (l.c.) found that the roach (Blatta orientalis) spent only 5 hours in activity and 19 hours in quiet, being most active between six in the morning and twelve at noon. The blowfly (Musca vomitoria), during the month of August, is quiet during the day and is most active from six to twelve at night.

The periods of activity and quiet are more definite and more easily distinguished among the vertebrates. Among the lower forms the periods are less frequent and of longer duration. A number of observations have been made upon fishes. Verill (1897) states that all fishes that he has observed remained immobile during the hours of the night. Pieron (l.c.), on the other hand, found some varieties of fishes that remained active all of the time. He does not believe that the nocturnal fishes are ever inactive.

Szymanski (l.c.) found that goldfish spend 8 hours in activity and 16 hours in quiet, being active during the day.

Szymanski states that the tree frog (Hyla arborea) during July and August spends only 3 hours in activity and the rest in quiet, two short activity periods alternating with two long quiet periods. He found the snake (Tropidonotus natrix) in September had an activity period of 2 hours and a continuous quiet period of 22 hours. With the lower vertebrates it is characteristic to find but two periods, one of activity and one of quiet. The activity comes during the day or night according as the animal is diurnal or nocturnal.

With the higher forms of vertebrates especially the mammals there is more variation in the amount of activity and quiet. The periods also alternate more frequently. Most birds, however, are like the lower forms of vetebrates. They tend to remain quiet dur-

ing the hours of the night and to be active during the day. Szymanski (l.c.) carried out some experiments with the canary and found it was continuously active from six in the morning until six at night. It remained quiet from six at night until six the next morning.

Szymanski (l.c.) worked with a number of mammals. He found the white, gray and dancing mouse spent about half their time in activity and half in quiet, the time of activity ranging from 10 to 14 hours. The dancing mouse showed one long activity period of 10 hours and seven very short periods alternating with periods of quiet. The white mouse had sixteen short periods of activity alternating with periods of quiet and the gray mouse twenty-three activity periods of even shorter duration during the twenty-four hours.

The white rat showed 10 hours of activity broken into ten short periods. The rabbit showed 12 hours of activity divided into 12 short periods and 12 of quiet similarly divided. The cat had only 4.5 hours of activity divided into seven different periods and the dog 6.75 hours divided into thirteen periods. The young infant showed 10 hours of activity and 14 hours of quiet. In all of these animals, with the exception of the mouse there is little difference in the amount of activity during the twelve hours of the day as compared with the twelve hours of the night.

Slonaker (1907) studied the spontaneous activity of white rats in revolving cages and found that the amount of activity varied with age. He found that the age of greatest activity as represented

by the number of revolutions of revolving cages ranges from 87 to 120 days. The rat spends much more time in rest than in activity and is more active at night.

Richter (1921) found that the white rat showed four to ten activity periods during the twenty-four hours and was most active during the night. He also found that the amount of activity decreased with age.

Dr. W. R. Miles (private communication) states that Dr. J. Aub has found great difficulty in studying the resting metabolism of rabbits due to the fact that they are never or very seldom inactive.

I can find no work that has been done concerning the amount of activity and quiet of the guinea pig. Allen (1904) states that the guinea pig seems to be more active in the dark than in the light but she made no experimental study. The general impression among animal experimenters seems to be that in the laboratory guinea pigs are unusually quiet animals. It is interesting to note, however, that guinea pigs apparently never assume a characteristic sleeping pose like that of a dog or rat or mouse, and that thus far I have failed to find anyone who recalls having seen a guinea pig sleeping.

CHARACTERISTICS OF THE GUINEA PIG

Many theories have been put forth concerning the original ancestor of the guinea pig, but so far the actual origin of most of the varieties of the present domestic guinea pig is unknown. Nehring (1889) believed that Cavia cutleri of Peru is probably the ancestor of the domestic guinea pig. It agrees closely with the guinea pig in cranial characteristics and it is found in a region where the guinea pig has been domesticated for a long period of time as witnessed by mummified guinea pigs having been found buried with the dead. Nehring (1893) crossed Cavia operea from Argentina with the guinea pig and the result was a fully fertile hybrid.

Castle and Wright (1916) obtained several wild specimens of Cavia cutleri from Peru and from a careful study they reach the following conclusions:

"The complete fertility of the hybrid produced by crossing wild Cavia cutleri with the guinea pig is striking in contrast with the sterility of hybrid between Cavia rufescens and the guinea pig as observed by Detlefsen (1914). This indicates that Cavia cutleri is the actual wild ancestor of the guinea pig or closely related to that ancestor. Since, however, Nehring has reported that Cavia operea from Argentina also produces fertile hybrids with the guinea pig it seems likely that these two species are closely related to each other and might interbreed freely if the respective ranges were

not completely separated. It seems possible also that both species have contributed to the production of the domesticated form or that still other species have contributed to producing it."

Dr. Glover M. Allen (private communication) believes that the common guinea pig now in general use as a laboratory animal is probably native to Brazil.

Among rodents the rat and the guinea pig represent extremes of a series in regard to the development of their young at birth. The young of the rat are born in a very immature condition. Their eyes are closed, they have no hair, and their nervous systems are entirely unmedullated. The guinea pig is born very mature, its eyes are open, it is covered with hair, and it is quite able to take care of itself at birth. Allen (1904) found its nervous system to be almost completely medullated.

Watson (1903) (p.63) found that the memory processes in the white rat were not present until the twelfth day and maturity was reached at the twenty-third to the twenty-seventh day (p.83). Allen (p.340) (l.c.) on the other hand, found that the guinea pig learned a simple path on the second day and upon the third day solved the most complex problem it was ever able to solve.

The gestation period in the guinea pig is 67-68 days (Minot 1891) (p.143) and the litters are small, usually two or three young. The weight at birth averages 70 grams (Minot) (l.c. p.109). The

young are weaned at the end of the second week and sexual maturity is reached at the fourth month, although there is a gradual increase in weight up to the twelfth month. Dr. W. E. Castle (private communication) states that he believes "the advanced stage of development at birth is a direct consequence of a long period of gestation or vice versa as you please to consider the cause and effect relation".

APPARATUS

The apparatus used to determine the amount of activity of the guinea pig was similar to the one used by Richter (1921) in his work on the activity of the rat, (Plate I). It consisted of an equilateral triangular cage 25 inches on each side. The bottom was made of plaster board reinforced on each side with narrow strips of wood. The sides were made of 14 mesh mosquito netting, 8 inches high. Each cage weighed about 2 pounds. This cage rested upon the points of three large screws one inch in length. The screws had their heads soldered to small metal discs about an inch in diameter. These discs rested upon rubber membranes which were stretched over the top of especially constructed brass cups. These cups were 1.25 inches deep and 2.12 inches in diameter and at the center of the bottom a metal nipple 1.25 inches long was inserted. Holes were bored in the table on which the apparatus was assembled and the metal nipples projected through these holes. The cups then rested upon the table. The rubber tubing from the three metal cup nipples was brought together by means of a glass four-way connection. A long piece of tubing joined the four-way connection to a Harvard tambour writing-lever. Any movement of the cage was transmitted by air pressure throught the cups to the tambour and then to the kymograph via the writing lever. The cages were made as light as possible so as to rest easily upon the rubber membranes and to increase their sensitiv-

ity. Respiratory movements were not recorded but all muscular movements were recorded including quiet eating, scratching, etc. The records were taken on a long-paper kymograph.

The guinea pigs were fatigued by being run in a revolving cage. The apparatus consisted of a wire drum 5.6 feet in circumference and 10.5 inches wide, (Plate II). A cardboard partition was put in the middle of the cage so that two guinea pigs could be run at the same time. The drum was driven by an electric motor, the speed being controlled by two sets of reducing pulleys and a rheostat. A cyclometer recorded the number of revolutions of the drum.

All activity experiments were carried on in a brick vault 20.3 feet long and 7.51 feet wide which was 15 feet below the surface of the ground. This vault in the former Physics Laboratory of Johns Hopkins University was especially constructed by Dr. Rowland for his dividing engine. It was designed to maintain a constant temperature and humidity and to be free from all vibrations. These variables had to be kept constant in the present experiments and thus the vault offered ideal conditions. A further advantage was the absence of noise. The temperature in the dark was 19.5° C and never varied more than one degree in either direction. When the room was lighted by two 75 watt nitrogen daylight bulbs the temperature rose about two degrees and then remained constant. The relative humidity in the dark was 42% and in the light 44% as measured by the sling psy-

chrometer. No one was allowed to enter the room except the experimenter, and then only long enough to feed the animals and change the paper on the kymograph.

MATERIAL

All the guinea pigs used in these experiments were of healthy stock and varied in size from 200 grams to 300 grams. They were all of the common short-haired variety. In all experiments when a group of animals was used, half were males and half were females. The guinea pigs were kept in the vault for at least a week before they were used in any experiment so as to become accustomed to the new environment. The food consisted of oats and water which the animals had in their cages all of the time and three times a week they were given cabbage and carrots. The bedding consisted of one or two inches of cut hay. The guinea pigs that were being used during an experiment were kept in the vault all of the time even when no record was being taken of their activity. The vault apparently offered a splendid environment for the growth and development of the guinea pig. The growth curve of the animals used followed closely the growth curve for guinea pigs as plotted by Minot (l.c.). It was found that if guinea pigs were taken upstairs into the animal room, after being in the vault for some time, they soon lost weight, became ill and frequently died.

The guinea pigs were handled constantly and soon became very tame. After a week or ten days they would not be frightened by the experimenter's entering the vault and instead of remaining quiet they would run about their cages squealing noisily. In only one

case did a guinea pig become sick in the vault and that was in one of the fatigue experiments. There were no deaths.

GENERAL ACTIVITY OF THE GUINEA PIG

ACTIVITY IN THE DARK:

As it is generally believed that the guinea pig is most at home and most active in the dark, the first set of experiments, which endeavored to put the guinea pig in his most natural environment, was carried on in the dark.

Six healthy guinea pigs, three males and three females, whose weight ranged from 182-316 grams, were chosen for the experiment. They were taken into the vault and each was put into a separate recording cage. They were given cut hay for bedding and oats and water. They were kept in their respective cages for three days before any records were taken of their activity so as to become accustomed to their new surroundings. The light was turned on for about fifteen minutes each morning during feeding time, but otherwise the room was in total darkness. There were no cracks where light could enter as the room opened by a tight fitting door into a larger room which was also dark. The doors both at the top and bottom of the steps which led into the vault were kept shut. There was therefore no possible way for any daylight to enter the rooms.

The experiment was started at nine o'clock in the morning and was continued for a week, every movement of the six guinea pigs being recorded throughout this period. A single kymograph sheet

contained the activity of the six guinea pigs for twenty-four hours. The activity of each guinea pig was recorded, one directly under the other, with a time line at the bottom marking each hour. Thus in a week seven separate records were obtained, each showing the activity of six guinea pigs for a period of twenty-four hours. Three separate weeks' records in the dark were made in all. One was made in the spring, one the following fall, and one a few weeks later in the fall.

A week's records were tacked on the wall in the order in which they were taken and a careful study was made of them. In all the records there was the same general picture. The guinea pigs showed almost continuous activity, (Plate IV). The activity was divided into two phases; 1) periods of "continuous" activity in which there were no rest or quiet periods, and 2) periods of "intermittent" activity in which there were a number of quiet periods varying in length from a fraction of a minute to ten minutes. There were no long rest periods whatsoever in any of the records. The periods of continuous activity varied in length from five minutes to several hours. These periods alternated with the periods of intermittent activity and were always considerably longer than the latter. There was a tendency for the six guinea pigs to be continuously active at the same time. This point will be discussed later in the paper. During continuous activity the movements were more violent than in the periods of intermittent activity.

Besides a careful study of the records, it was thought advisable to devise a method by which to obtain a numerical criterion of the actual amount of activity shown by each guinea pig. In this way the amount of activity of the six guinea pigs could be compared with each other on the same and on different days. Also the activity of one guinea pig could be compared on the seven different days. We hoped to obtain a numberical figure which represented the approximate amount of activity of a guinea pig in the dark for twenty-four hours.

The method finally decided upon was to measure all activity periods which contained no quiet periods of 2.5 minutes or more in length. This was done by means of a small map measurer, (Plate II b). The instrument was set at zero, placed at the beginning of an activity period, and run along until it came to a quiet period an eighth of an inch or more in length. The instrument was then carefully lifted from the paper and put down again on the other side of this quiet period and run along until another quiet period an eight of an inch or more in length appeared in the record. The total amount of activity in feet and inches was then recorded. Only twenty-three hours were measured, the hour between nine and ten in the morning not being counted. During this hour each day the paper was changed on the kymograph and there was a loss of time varying from five minutes to half an hour. The guinea pigs were continuously active at this hour because they were fed and also were disturbed by the light and the presence of the experimenter. As the conditions were not the

same at this time compared with the other hours of the day, because of these disturbing elements, it was thought best to eliminate this hour.

The total length of paper which represented the twenty-three hours was measured from the time line, and the number of inches of paper which represented one hour was determined by dividing the total length by twenty-three. The total number of inches of activity was then divided by the length which represented one hour and the amount of activity in time was determined. The results were tabulated in chronological order and the averages obtained. By practice a fair amount of accuracy was obtained in measuring the amount of activity and the error did not vary more than plus or minus three per cent.

By this method the guinea pigs showed extreme activity in the dark. Out of the twenty-three hours, the smallest amount of activity for any one animal was 17.5 hours and the largest amount 23 hours. The average for the six guinea pigs for seven days varied from 19.69 hours to 21.73 hours out of the twenty-three, and the average activity for the six guinea pigs in the dark was 20.8 hours out of the twenty-three, or at the rate of 21.6 hours out of the twenty-four. The absolute activity for twenty-four hours was actually greater than the calculated 21.6 hours, since during the anticipatory excitement of feeding the animals were in continuous motion. The small amount of rest was broken up into numerous short periods averaging three to four minutes in length. The longest rest period on any record was

ten minutes.

The quiet periods of less than one eighth of an inch were measured with the total amount of activity for two reasons. First, in measuring the length of the activity periods it was impossible to leave out the quiet periods of less than one-eighth of an inch without introducing a considerable error. The instrument would have to be lifted from the paper a great many more times and this factor increases the possibility of error in the total length. Secondly, the quiet periods of less than one-eighth of an inch are approximately one thirty-second to one sixteenth of an inch in length which represents but .6 to 1.2 minutes in time. It was found by observation that slight movements such as quietly chewing were not recorded by the levers and these might account for some of the periods. Also the guinea pig is extremely sensitive to sounds even those caused by the gnawing or scratching of other guinea pigs. Whatever the cause of these momentary quiet periods they are more or less constant in all of the records and as all the records are measured in the same way they can be compared with each other without introducing an error.

ACTIVITY IN THE LIGHT

The next set of experiments was carried out under exactly the same conditions as those in the previous experiment with one exception. The room in this case was constantly lighted by two 75 watt nitrogen daylight bulbs which were suspended directly over the cages. The same set of guinea pigs was used as in the above experiment. They were left in their separate cages for three days, so as to become accustomed to the light before any records were taken.

The experiment was started at nine o'clock in the morning and was continued for a week. Two sets of records in the light were taken about two months apart. In the first set, the paper was changed every twenty-four hours and in the second the drum was run faster and the paper was changed every twelve hours. The records obtained were tacked on the wall beside the set taken in the dark and the two were compared. There was practically no difference in the two sets of records, (Plate V). There was the same general picture of extreme activity broken up into periods of "continuous" activity and periods of "intermittent" activity. These periods were essentially similar in both dark and light records and the rest periods were not typically longer or any more frequent in the light than in the dark.

By actually measuring the activity periods, as in the previous experiment, the following figures were obtained: out of the

twenty-three hours the smallest amount of activity for any one guinea pig was 15.6 hours and the greatest 22.6 hours. The average for the six guinea pigs for seven days varied from 19.4 hours to 21.53 hours and the average activity for the six guinea pigs for a week in the light was 19.83 hours out of twenty-three or at the rate of 20.64 hours out of the twenty-four. Thus in comparing the total activity of the six guinea pigs in the dark with the total activity in the light, there is one hour less activity in the light per day, or a decrease of 4.6 per cent.

DISTRIBUTION OF ACTIVITY

The guinea pig divides his time into periods of "continuous" activity and periods of "intermittent" activity. It is difficult to count the number of periods of each, since the periods frequently run into each other. Roughly, they vary from fourteen to twenty-three of each. The continuous activity periods vary in length from five minutes to three or four hours and their length does not correlate in any way with the following periods of intermittent activity.

In Plate III, 1, the continuous activity periods of the same guinea pigs are plotted on three different days. Periods were chosen of over ten minutes in length and which were broken by no quiet periods. There is no tendency for the guinea pig to be active at the same time each twenty-four hours. The activity seems to be evenly distributed over the twenty-four hours and there is no nocturnal or diurnal rhythm. The periods of "continuous" activity are greater in length than the periods of "intermittent" activity.

In Plate III, 2, the "continuous" activity periods of three different guinea pigs in the dark are plotted for twenty-four hours. Plate III, 3, shows the activity of the same three guinea pigs for twenty-four hours in the light. Three successive days of each are plotted. In the original records there seems to be a tendency for the guinea pigs to stimulate each other to activity. They appear to

be all "continuously" active at the same time. This does not show up as well in the plotted picture as in the original records, Plates IV and V.

COMPARISON OF THE ACTIVITY OF SINGLE ANIMALS AND GROUPS

At this point, the question arose as to the possibility of the six guinea pigs stimulating each other and thus increasing their normal amount of activity. In order to decide this question an experiment was carried out in which a guinea pig was placed alone in the vault and his activity recorded. This procedure was repeated using different guinea pigs and two days' records were taken of each animal. In two further experiments the activity of two guinea pigs and a group of six guinea pigs was studied. The same guinea pigs were used throughout the experiments. The work was carried out in the dark.

The records were measured and the average activity for the different groups was determined. The results were as follows:

Activity for one guinea pig alone:	20.55 hours
Activity for two guinea pigs, side by side but in separate cages:	21.05 hours
Activity for six guinea pigs in a group of separate cages:	20.38 hours

From these results there is apparently no significant difference in the amount of activity of the guinea pig whether alone or in groups.

INFLUENCE OF AGE UPON ACTIVITY

Slonaker (1907) and Richter (1920) both found in the study of the white rat that the amount of activity decreased with age. A set of experiments was therefore carried out to see if this was true in the case of the guinea pig.

Records were taken in the dark of the activity of four young guinea pigs one month old. Records were also taken of four adult guinea pigs between eight and nine months. We had at hand records of six guinea pigs three months old and of the same guinea pigs six weeks later. The results obtained by measuring the amount of activity are found in Tables 2, 3, 6, 7. Briefly they are as follows:

Average activity of guinea pigs one month old	21.19 hours
" " " " " three months old	21.6 "
" " " " " four and a half months old	20.38 "
" " " " " eight months old	21.18 "

There is apparently little difference in the amount of activity of guinea pigs ranging in age from one to nine months. The records of the older guinea pigs have the same general appearance as those of the younger. The amplitude of the movements is higher with the older guinea pigs because of their increase in weight.

RELATIVE ACTIVITY OF MALES AND FEMALES

In the experiments on the activity of guinea pigs in the dark and in the light in each case three male and three female guinea pigs were used. A study was made here of the activity of each group to see if the amount of activity varied with the sex. Richter (1921) found in the case of the white rat that in the revolving drum the females were more active than the males.

From Table 2 it is found that in the dark the average amount of activity of three female guinea pigs is 21.40 hours and of three male guinea pigs 22.01 hours. The male guinea pigs show in this case an increase of activity over the females of .61 hours. In the light, from Table 4, the females have 20.44 hours of activity and the males 21.18 hours, with an increase in the case of the males of .74 hours. Thus both in the light and in the dark the male guinea pigs show a slightly greater activity than the female guinea pigs.

THE INFLUENCE OF FOOD UPON ACTIVITY

The guinea pig is an herbivorous animal and spends most of his time eating. When he is not eating the food provided he nibbles at pieces of hay and sits quietly chewing. An attempt was made in this set of experiments to determine the part that food plays in the activity of the guinea pig. If food is partially or completely removed will the guinea pig still continue to be as active?

Food one hour a day.

The same six guinea pigs were used as in the previous experiment and the work was carried out in the dark. All food and bedding was removed from three of the recording cages and paper bedding was substituted for the hay. At nine o'clock in the morning the six guinea pigs were weighed and the experiment was started, three guinea pigs being without food and three controls with food. The next morning at nine o'clock the six animals were again weighed and the three guinea pigs without food were given food for one hour. Water was left in the cages all of the time. At the end of the hour all the food was again removed from the same three cages. This was continued for seven days and records were carefully taken of the amount of activity and rest. The guinea pigs were always weighed at nine o'clock in the morning just before they were fed. The three control animals were also weighed at this time.

The amount of activity shown on each record was then

measured by means of the map measurer and the data were tabulated. As in the previous experiments, the activity for twenty-three hours only was measured. The time between 9 a.m. and 10 a.m., when the guinea pigs were fed and the recording paper was changed, was not counted. From the data obtained the average amounts of activity for the three guinea pigs fed for one hour a day for seven days were 21.33 hours, 22.0 hours and 20.93 hours, making an average of 21.42 hours of activity in the twenty-three hours for the three guinea pigs, or at the rate of 22.2 hours in the twenty-four; the three control guinea pigs had averages of activity for seven days of 21.95 hours, 21.05 hours and 21.5 hours, showing an average of 21.5 hours of activity in twenty-three hours, or at the rate of 22.3 hours out of twenty-four hours. Thus the three guinea pigs without food showed no significant decrease in activity although the amount of food eaten each day was considerably less than that of the three control guinea pigs.

Since there was no decrease in activity, we expected to find a loss in weight each day and this was actually the case. One guinea pig showed a loss in weight of 41 grams the first day and only had 13 hours of activity. The cause of this great loss both in weight and activity was quite obscure. Guinea pig F did not show any loss in weight the first day and guinea pig D showed a loss of 10.5 grams. The controls showed gains of 6.5 grams, 5 grams and

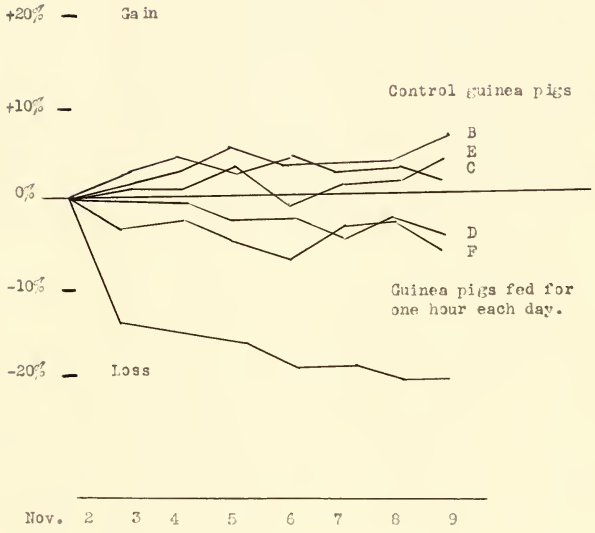

Figure 1 - Percentage loss in weight per day of three guinea pigs fed for one hour a day for seven days. The three controls (upper curves) had food in their cages throughout the experiment. See Table 9 for complete data.

5 grams the first day. The average loss in weight for the week for the three guinea pigs without food was 29.8 grams while the average gain for the control animals was 11.0 grams. It is fair to assume that if the three guinea pigs without food had been given their normal rations for the week they would not only have maintained their original weight but would probably have shown a proportional increase of weight of approximately 11.0 grams like the controls. Therefore the total average loss in weight for the three fasting guinea pigs may be considered as 40.8 grams or 13.6 grams per guinea pig. Thus the fasting guinea pigs maintained their normal activity, but at the expense of their body weight.

No Food.

As a check on the above experiment another one was carried out in which three guinea pigs were not given any food at all for three days. This time the food and cut hay bedding was removed from three of the cages and no paper bedding was substituted. Wire moaquito netting was put over the bottom of the cages so as to prevent the guinea pigs from nibbling at the cardboard. Three healthy guinea pigs were chosen all weighing over 300 grams. Three others were chosen for controls.

The guinea pigs that were to be starved were weighed and the experiment was started. The following day at the same hour the three guinea pigs were again weighed and again on the second and third day. At the end of the first day the three guinea pigs without food seemed very restless and ran about their cages squealing. On the second day one seemed sick while the other two were quite lively. On the third day all three sat humped up with their eyes partly closed and seemed to move with difficulty. They were given food gradually and within a week they were weighed again and all but one had regained his original weight.

The records obtained were measured in the usual way. The first day the starved guinea pigs showed an average amount of activity of 15.6 hours while the controls had an average of 18.4 hours. On the second day, the starved guinea pigs showed an average activity of 18.7 hours as compared with 18.5 hours shown by the controls. On the

third day, the three starved guinea pigs showed 7.1 hours, 7.1 hours and 7.6 hours of activity respectively, making an average of 7.3 hours. The controls had 17.3 hours. Thus on the first and second day there was little falling off of activity as compared with the controls but on the third day the amount of activity decreased over 50 per cent.

In comparing the activity with the loss in weight, we find the loss the first day was the least, i.e. 6.0 grams, 6.5 grams and 7.0 grams. The loss on the second day was much greater - 24.0 grams, 33.5 grams, and 31.5 grams. This was also the day on which the average amount of activity was the greatest. On the third day the loss of weight was 21.5 grams, 19 grams, and 21.0 grams. As in the previous experiment the three guinea pigs continued their activity at the expense of their body weight up to a certain point.

It is interesting to note in this experiment that the control guinea pigs did not show as much activity as was found in previous experiments. As these guinea pigs were the same as were used in many of the other experiments this may have been due to the influence of the starved guinea pigs. The control guinea pigs showed their smallest amount of activity on the third day when the activity of the starved animals had fallen off over 50 per cent. The reduced activity of the fasting guinea pigs may have had an inhibiting effect upon the controls.

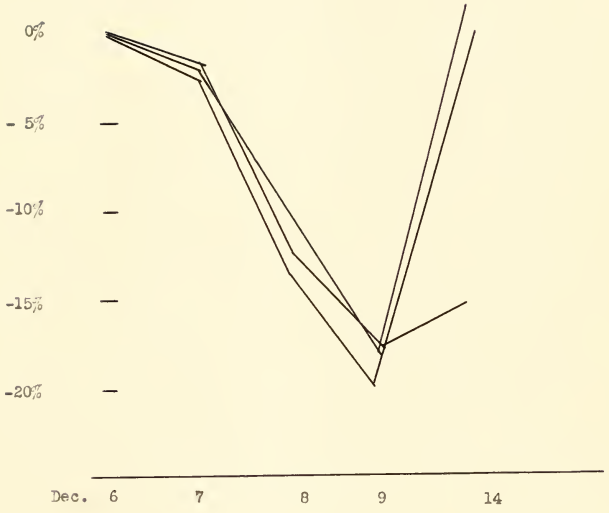

Figure 2 - Starvation Experiment. Three pigs were kept without food for three days. The graph shows the percentage weight-loss with subsequent recovering. See Table 11 for complete data.

THE INFLUENCE OF PHYSICAL EXHAUSTION UPON ACTIVITY

In this set of experiments we studied the relation between physical exhaustion produced by forced running in a motor-driven drum and subsequent activity. In some of the experiments a separate food cage was connected to the main cage by a small opening. The food cage was set upon separate tambours and all movements were recorded independently on the drum. The purpose of this was to determine the amount of time the guinea pig spent in the food cage.

Six guinea pigs were used varying in weight from 249 - 314 grams. Other guinea pigs were used as controls. A guinea pig was weighed and placed in the motor-driven drum and made to run until he was exhausted. An animal was considered exhausted when he lay on his back or side and let the cage slide under him and when he remained in the same position for some minutes after the drum was stopped. He was again weighed and immediately taken down into the vault and put into the recording cage for two hours. The records were spread out more than in the earlier experiments in order to emphasize individual movements. The six guinea pigs were exhausted in the same manner and records were taken of their behavior afterwards.

In all of the records the guinea pigs remained quiet for ten or fifteen minutes and then began eating. They ate continuously while they were in the cage. The records show a continuous line of small movements such as are registered by eating and there are few

vigorous movements. Where the food cage is attached the records show that within a few minutes the guinea pig entered the food cage and remained there for what remained of the two hours, eating all of the time. The records of the control guinea pigs showed more vigorous movements and considerably less eating movements.

Upon observation the three guinea pigs sat humped up beside the dish of food, with their eyes partly closed but chewing vigorously. They did not move their position when the experimenter entered the vault or show any fear when touched. They did not respond to any stimulus except the one aroused by the desire for their food.

It seems therefore from these results that eating is more essential than sleeping in the recovering of guinea pigs from fatigue.

It is interesting to note that the heavier the guinea pig and consequently the older the longer it took for the guinea pig to become exhausted. Data concerning the weights of the pigs and the times and distances run are given in Table 12 in the appendix.

THE INFLUENCE OF TEMPERATURE UPON ACTIVITY

During the first part of the experimental work we observed a constant tendency in our guinea pigs to stretch out on the bottom of the cage and remain inactive for long periods when the temperature was between 75° - 80° F. This was not an inhibition because of fear as the guinea pigs were all very tame. These long periods of inactivity were believed to be caused by the high temperature and the matter was further investigated by the following experiment.

Three young guinea pigs were put into separate recording cages in a small room in the vault. The rubber tubing from the cages was passed through small holes in the door frame and connected with the recording device outside the door. The door was kept shut and was opened only a few minutes each day to give the guinea pigs fresh water and food. The room was heated by a Majestic electric heater. A Fries thermograph recorded the temperature.

Records were taken of the amount of activity of the guinea pigs at the normal temperature of the vault, 65° F., for four days. The electric heater was then turned on for four days and records were taken of the activity of the guinea pigs. The heater was turned off for twenty-four hours and then put on again for four days, and activity records were taken.

The records were measured in the usual way and the amount

of activity for each day is recorded in Table 12 in the appendix. The average amount of activity for the three guinea pigs at the normal temperature of the vault, 65° F., was 20.8 hours. As the temperature increased the amount of activity decreased. (See Figure 3). At 79° there was 19.1 hours of activity and at 85° there was 12.1 and 12.5 hours of activity. When the electric heater was turned off for twenty-four hours the temperature fell to 79° and the amount of activity rose to 15.1 hours. The room was again heated and the temperature rose to 87° and the amount of activity decreased to 7.9 hours on the last day.

The general appearance of the records is quite different for the days when the temperature was high as compared with the normal activity records. The "continuous" activity periods are very short and are broken by short quiet periods. The amplitude of the movements is considerably reduced. There are long periods of absolute quiet which are never found in a normal activity record. We find from this experiment that there is a decided decrease in the activity of the guinea pig with an increase in temperature.

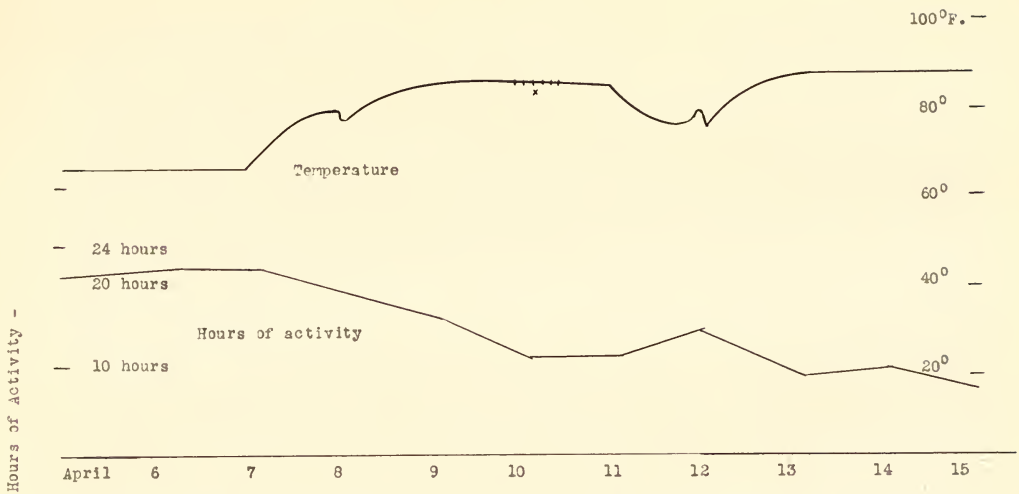

Figure 3 - Showing the influence of temperature upon the amount of activity of the guinea pig. See Table 13 for complete data.

* Changed paper on thermograph.

A MEASURE OF FATIGUE IN THE GUINEA PIG

In connection with a study of the relation between fatigue and susceptibility to pneumococcus infections in guinea pigs, Nicholls and Spaeth (1922), we attempted to find an objective criterion of fatigue in guinea pigs. By activity records we hoped to show a definite decrease in activity with each increase in the amount of work done by the guinea pigs.

Four healthy guinea pigs were chosen for the experiment varying in weight from 245 - 330 grams, two males and two females. Four other guinea pigs of about the same weight were chosen as controls. The eight animals were taken down into the vault and kept in an especially constructed cage. This cage was made of 14 inch mesh mosquito netting ten inches high with a bottom of plaster board covered with wire meeting. It was 5 feet long and 1.5 feet wide. The cage was set up on six brass wire springs which were so constructed as to be practically as sensitive to movements as the recording cages, which were set up on rubber tambours. The purpose of this was to accustom the guinea pig to the spring or vibration of the recording cage and thus eliminate any stimulating effects which might result when the animals were put into the recording cages for the first time. This reserve cage moved slightly up and down with each movement of the guinea pigs. Food, water and cut hay were kept in the cage at all times as in the recording cages.

The guinea pigs were first kept in the "reserve" cage in the vault for one week so as to become accustomed to the new conditions of temperature, humidity and extreme quiet. They were handled frequently so as to eliminate as far as possible the fear element and become accustomed to the experimenter. Also during the week, they were put into the revolving cage for fifteen minutes at a time and taught to run smoothly instead of sliding. Some learned very quickly in the first trial while others took much longer but once they learned they would keep running evenly for hours.

On the eighth day four guinea pigs were put into four separate recording cages and a record was taken of their activity for two hours. The kymograph was then stopped and two of the guinea pigs were taken upstairs, weighed, and put into the revolving cage. As stated earlier in the paper, a cardboard partition in the middle of the revolving cage allowed two guinea pigs to be run at the same time without interfering with each other and they thus had a uniform amount of exercise. The guinea pigs were run until the cyclometer registered two hundred and forty revolutions or .256 mile. The speed of the cage was so adjusted that this took approximately one hour. The guinea pigs were then taken out, weighed, and again put back in their former recording cages and another record was taken of their activity for two hours. At the same time records were also taken of the two control animals which had not been exercised and had remained in the vault. The experiment was then repeated with the four

other guinea pigs, two being used for controls and the other two exercised for one hour and records were obtained for two hours before and after fatigue.

The following day the above experiments were repeated with the eight guinea pigs but this time the animals were exercised for one and one half hours or 360 revolutions, making a run of .384 mile.

On the third day, the guinea pigs were exercised for two hours or 480 revolutions, making a run of .512 mile and records were obtained.

On the fourth day, the animals were rested. This was thought advisable so as to eliminate accumulative fatigue which might be present. While a guinea pig might not show any or very little fatigue after being exercised on a certain day, the small amount of fatigue present might hang over until the next day and when he is again exercised he might show more fatigue than if there had been a day between. This might be especially significant with runs of two or three hours.

On the fifth day, the guinea pigs were exercised for two and one half hours or 600 revolutions, making a run of .640 mile.

On the seventh day, the guinea pigs were exercised for three hours or 720 revolutions, making a run of .768 mile.

In order to get a more accurate index of the actual amount of fatigue present than that obtained by a careful study of the records

a method was devised in which on a single record every movement of the guinea pig which was registered by a small white mark was counted, and the total movements noted for both the first and second hours before and after fatigue. This was done on the records obtained before and after fatigue for each guinea pig for each of the different periods of exercise, making forty records in all. The numbers of movements for each guinea pig were tabulated and the activity of the first hour before fatigue was compared with the activity of the first hour after fatigue and the percentage difference calculated. Also the activity of the second hour before fatigue was compared with the activity of the second hour after fatigue and the percentage increase or decrease noted. This was worked out for each guinea pig, including the controls. A record was kept of the loss in weight of each pig after exercise.

From a study of the data obtained it was found that in comparing the activity of the control guinea pigs there was considerable variation in the number of movements of the first hour of the first record and the first hour of the second record and similarly between the second hour of the first record and the second hour of the second record. Sometimes there was an increase in activity and sometimes a decrease. In all the records in which there was an increase of activity the average increase was + 68.7% and in all the records in which there was a decrease the average decrease was - 21.37%. Thus

the average fluctuation of the controls was from - 21.37% to + 68.7%.

The four guinea pigs fatigued for one hour showed an average percentage difference for the first hour before fatigue and the first hour after fatigue of - 3.0% and the difference for the second hour before and after fatigue was + 5.7%. Thus for one hour of exercise the four guinea pigs showed in the first hour a falling off of activity equal to - 3% and in the second hour an increase in activity of + 5.7%. The control records obtained at this time showed a decrease in activity of - 7.3% for the first hour and an increase of activity of + 2.0% for the second hour. Here the guinea pigs showed no fatigue whatsoever. (See Fig. 4).

The records for the same four guinea pigs exercised one and one half hours showed an increase in activity of + 3.25% for the first hour and a decrease of - 14.7% for the second hour. The controls at this time showed an increase of + 48.0% and + 66.3%.

When the guinea pigs were run for two hours there was a decrease in activity of - 27.4% for the first hour and a decrease of - 34.6% for the second hour. If we take into consideration the fact that the control guinea pigs showed an average fluctuation of - 21.37% to + 68.7% any percentage to be a criterion of fatigue would have to fall below this number. Since the two figures above are greater than this average decrease we concluded that a small amount of fatigue was present.

When the guinea pigs were run for two and one half hours, there was an increase in activity of + 9.97% for the first hour and + 7.4% for the second hour; while the controls showed a decrease of - .2% and an increase of + 23.0%.

When the guinea pigs were run for three hours, there was an increase in activity of + 10.6% for the first hour and an increase of + 3.8% for the second hour. The controls showed an increase of + 42.1% and + 55.2%. The loss in weight varied from 0 gram to 15 grams. The average loss in weight for the first hour of exercise was 1.5 grams, for one and one half hours 2.1 grams, for two and one half hours 4.6 grams, and three hours 8.2 grams.

In all the data obtained, in only one instance, that of two hours of activity, was there the slightest evidence of fatigue. Since the guinea pigs were fatigued for two hours the day after they were fatigued for one and one half hours, this case may perhaps be considered one of accumulative fatigue especially since the next records taken two days later with an increased amount of exercise showed no fatigue whatsoever. Thus the guinea pig was not fatigued but on the contrary was trained to run for long periods without becoming fatigued. In this case, the animals showed no fatigue at all, after running .768 mile while in the previous experiment guinea pigs of about the same weight were completely exhausted after running .73 mile and .77 mile.

The experiment was not carried out any further because unfortunately one guinea pig became sick and another injured his foot while running. It is interesting to note, however, the extreme endurance of the guinea pig with a very small amount of training.

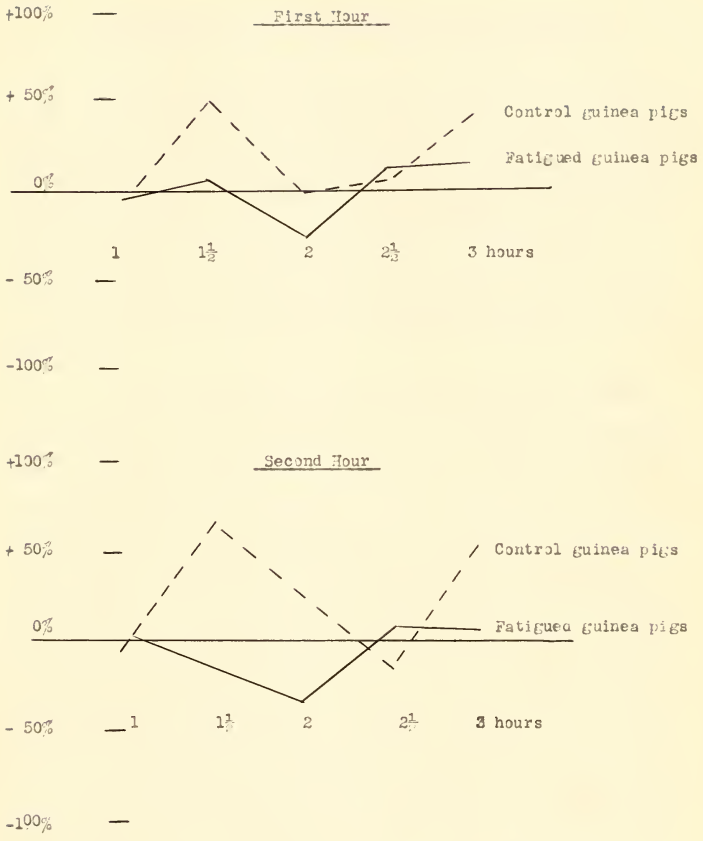

Figure 4 - Average fluctuation of activity the first hour (upper curve) and the second hour (lower curve) for fatigued guinea pigs and controls. See Table 14 for complete data.

THE NATURE OF THE ACTIVITY AND REST OF THE GUINEA PIG

From the records obtained of the activity of the guinea pig, it was found the activity was divided up into periods of continuous activity and intermittent activity. The latter contained numerous short quiet periods. The question therefore arose: Is the guinea pig practically continuously active with just snatches of rest or does he actually go to sleep and move in his sleep? The only way to settle the question was to watch the guinea pigs and find out by observation.

For this experiment a hole 5 inches long and 2.5 inches wide was cut in the door which led into the room where the experiments were in progress. The guinea pigs were placed as near the door as possible and a foot from the floor. It was found that only four cages could be conveniently observed at the same time. Long narrow mirrors were placed beyond the two farthest cages to aid in seeing the faces of the guinea pigs when their backs were turned toward the observer. The room was lighted by two 75 watt, nitrogen, daylight bulbs hung low over the cages. The observer sat on a stool on the other side of the door with his eyes about six inches from the hole.

The experiment was started at eleven-thirty in the morning and continued until eleven-thirty the next morning. During the day the observer watched for periods of two to four hours but from nine o'clock in the evening until seven the next morning the shifts were

never over two hours. This was to prevent loss of interest from fatigue on the part of the observer. The four guinea pigs were watched constantly and every movement and any signs of rest were carefully noted. Observations concerning the state of each of the guinea pigs were written down every five minutes and in many cases more often. The original data are included in the appendix.

The following facts seem worth recording. The guinea pigs divided their time into constant activity and intermittent activity. During the former they ran about their cages, with occasional leaps and jumps, called out to each other, tried to climb up the sides of their cages and gnawed at the wire netting or drinking cups. They would play with their food, dig in the food dish, and scratch for choice bits in their bedding. They were wide awake and free fron any fear. During these periods all the guinea pigs were more or less simultaneously active. Their activity would increase to a certain pitch and gradually they would quiet down again. These periods were longer than the less active periods and more frequent. They would vary greatly in the pitch to which the activity rose.

The intermittent periods were slightly different. They might be divided into fear, quiet eating, and actual rest. The guinea pigs in this experiment seemed to be conscious most of the time of the presence of the observer, but this factor did not disturb them to a great extent as they were all very tame. However,

moving the stool or dropping a book would startle them and they would sit quiet watching the hole as long as fifteen minutes at a time. These periods of fear were rather frequent due to the short shifts.

The guinea pig would often sit beside the food dish eating quietly and it was noticed that very slight movements such as chewing slowly did not record on the drum. The guinea pig spends most of his time eating. The actual rest periods were few and of short duration. A guinea pig would relax and settle into a little heap in a corner of the cage and even put his head down but he would never stay quiet for more than a minute or two at a time. He would constantly move, yawn, stretch himself, and make movements with his jaws. He would remain in this quiet state for some time but he would continually be interrupted by something and then settle down again. In these rest periods, the guinea pig would frequently partly close his eyes but in only one instance did an observer state a guinea pig had his eyes completely closed.

The actual amount of activity was measured on the record and also for the three succeeding days. It was found that during the twenty-four hours of observation, there was a considerable falling off from the normal amount of activity as previously determined. As stated above the guinea pigs seemed conscious of the observer and there was probably an inhibition from fear. This inhibition per-

sisted to a less extent the next day and disappeared the second day. The exact data are shown in the appendix.

COMPARATIVE ACTIVITY OF THE GUINEA PIG AND THE RAT

Before completing the experiment on the normal behavior of the guinea pig it was thought advisable to make some comparative studies with another animal. The white rat was chosen for this purpose for two reasons. It belongs to the same order as the guinea pig and its size is convenient. A male white rat is not much smaller than a young guinea pig. Furthermore, Richter (l.c.) has made an extensive study of the behavior of the rat.

In these experiments a study was made of the activity of the guinea pig and rat when together in the vault and also when alone. Any stimulating effects the animals might have on each other were noted. Any diurnal effects in the activity of the rat and guinea pig were observed. The animals were all males and were about two and a half months old. The four animals were put into separate recording cages in the vault with a rat alternating with a guinea pig. As the cages were arranged in the form of a square a rat had a guinea pig on each side of him and a rat opposite him. All four cages were covered with mosquito netting. The wire netting was necessary to prevent the rats' escaping from their cages. It was put over the cages of the guinea pigs so as to make the conditions the same. The animals were given their customary diet. The guinea pigs had cut hay for bedding and oats and water. The rats were given paper bedding

and oatmeal and milk. The experiments were carried on in the dark.

In the first experiment the four animals were taken into the vault and records were taken of their activity for periods of twenty-four hours. The records were then measured as in the previous experiments. This time the amount of rest was determined as well as the amount of activity. The two guinea pigs in four days showed an average activity of 22.28 hours while the rats showed 11.5 hours. Thus the guinea pig was almost twice as active as the rat. The guinea pig showed an average of 1.75 hours of rest and the rat an average of 12.5 hours. The guinea pig spent 93% of the twenty-four in activity and 7% in rest, while the rat spent 48% of the time in activity and 52% in rest.

There is a possibility in the above experiment that the rats and guinea pigs might have influenced each other to greater or less activity than normal. Therefore another experiment was carried out, in which the rats and guinea pigs were put in the vault alone and their activity recorded. The two guinea pigs were taken into the vault and their activity was recorded for two days, then they were removed and the two rats were taken down and their activity was recorded for two days. The guinea pigs showed an average activity of 21.25 hours and the rats an average activity of 9.87 hours. In the same period the guinea pigs showed 2.77 hours of rest and rats 14.1 hours. Thus the guinea pigs when alone spent 89% of their total

time in activity and 11% in rest. The rats spent 41% of their total time in activity and 59% in rest. If we consider 9.87 hours, the amount of activity when the rat was alone as his normal activity, the relative increase in activity when the rat was with the guinea pig is 16.5% while the guinea pig showed an increase of only 4.8%. The extreme activity of the guinea pig may have disturbed the rat and prevented him from taking as much rest as would normally be the case.

In comparing the amount of activity during the day with the amount of activity during the night, the guinea pig and the rat are quite different. The day is taken from six in the morning to six at night and the night from six in the evening to six the next morning. The guinea pig shows 10.4 hours of activity at night and 10.8 hours during the day. The rat shows 6.27 hours of activity at night and 3.6 hours during the day. There is, therefore, an increase of activity at night of about 80% which agrees with the well known nocturnal habits of the wild rat. The absence of a distinctly nocturnal habit in the guinea pig is strikingly demonstrated both by the above figures and in many of the other experiments recorded in this paper.

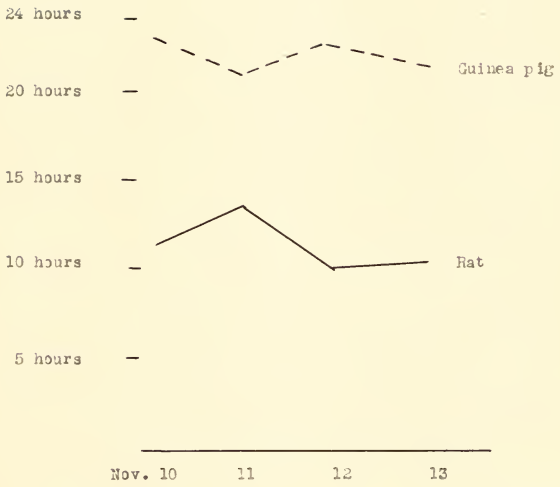

Figure 5 - The average activity of two guinea pigs and two rats on four successive days. See Table 17 for complete data.

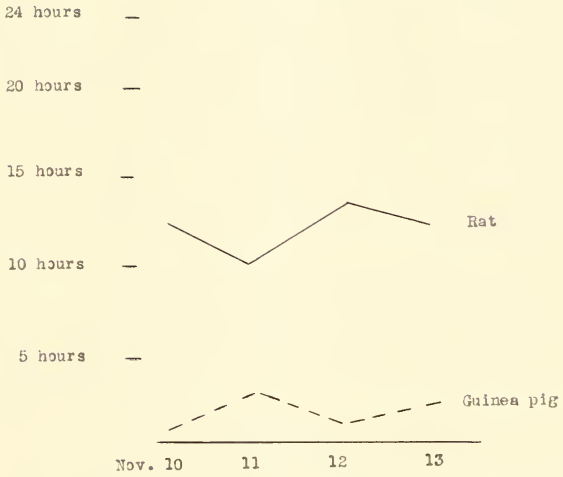

Figure 6 - The average rest of two guinea pigs and two rats on four successive days. See Table 18 for complete data.

CONCLUSIONS

1. When guinea pigs are placed in an environment free from all external stimuli and under constant conditions of temperature (ca. 68° F.) and 42% relative humidity, they exhibit a state of hyperactivity. There are no periodic alternations of complete rest and activity. The time is divided into periods of "continuous" activity and "intermittent" activity. During the former they are continuously active and in the latter the periods are broken by small rest periods averaging three to four minutes in length. There is no nocturnal or diurnal rhythm. In the dark, at a temperature of 65° F., they show an average activity of 21.6 hours out of the twenty-four.

2. With constant illumination and the same temperature as above, guinea pigs show an average activity of 20.64 hours out of the twenty-four. There is thus approximately 5% less activity in the light than in the dark.

3. In comparing the activity of single animals and groups it was found that the presence of other normal guinea pigs does not significantly effect the activity of a single pig.

4. There is apparently little difference in the amount of activity of guinea pigs ranging in age from one to nine months. The young guinea pigs showed an average activity of 21.19 hours, the three month

animals 21.6 hours, and the nine month old guinea pigs 21.18 hours.

5. In comparing the activity of the sexes, the male guinea pigs showed a slightly greater average activity than the females. In the dark the difference is 2.8% and in the light 3.4%.

6. Guinea pigs fed for an hour a day showed a slightly higher average activity than when they had food in the cage all of the time. They showed in a week, however, an average loss in weight per guinea pig of 13.6 grams.

7. When three guinea pigs were given no food for three days, there was a falling off of activity from 15.6 hours to 7.3 hours. There was also a rapid decrease in weight.

8. When guinea pigs were fatigued to the point of extreme exhaustion in a revolving cage, upon being put back into their recording cages, they immediately started to eat and continued for at least two hours. It seems from these results that eating is more essential than sleeping in the recovery of the guinea pig from fatigue.

9. The amount and distribution of the activity of the guinea pig is influenced by the external temperature. At high temperatures (80 - 85° F.) the normal activity of the guinea pigs drops off over 50%. At a high temperature they show short activity periods and long periods of quiet.

10. If a guinea pig is exercised by being forced to run in a revolving drum he can be trained to run as far as .768 miles without showing any fatigue whatsoever.

11. By observation it was found that during "intermittent" activity guinea pigs would settle into a relaxed condition but would never remain quiet for more than two or three minutes at a time. In these short rest periods the guinea pig would partly close his eyes and sometimes rest his head on the hay bedding. The guinea pig spends the greater part of his time eating.

12. In comparing the guinea pig with the white rat, the guinea pig was found to spend 89% of the twenty-four hours in activity and 11% in rest. The rat was found to spend 41% in activity and 59% in rest. The activity of the guinea pig was evenly divided between the day and the night. The rat was found to be 90% more active at night than in the day.

13. It is certain that sleep does not play a role in the normal life of the guinea pig comparable to the sleeping of rats, mice and other mammals.

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APPENDIX

Observation Experiment

Pigs heard the noise I made in getting settled and became quiet in a few minutes and began to eat.
11:40 - 1 violently jumped around, rest eating.
11:50 - 2 sitting quiet, eyes open watching hole. (I kicked door accidently.)
11:53 - 3 sitting quiet, eyes open watching hole.
12:00 - 2 and 3 sitting quiet watching hole, 1 and 4 eating.
12:05 - 1 and 4 sitting quiet, eyes open watching hole.
12:10 - All sitting quiet, eyes on hole, seem to be conscious of my presence.
12:20 - All resting, eyes open or partly closed. Relaxed appearance. More a state of rest than sleep. Move frequently, nibble piece of straw, yawn, scratch themselves, etc.
12:25 - 3 started in to eat, 1 also.
12:27 - 2 began to eat, 4 only one resting.
12:35 - All eating or cleaning themselves, 4 still quiet, eyes half closed for short periods of a few seconds.
12:40 - 3 and 4 quiet.
12:50 - 1, 3 and 4 quiet, 2 eating.
1:00 p.m. 2, 3 and 4 moving about, 1 resting.
1:03 - All eating.
1:06 - 2 quiet, ears twitch, eyes not visible.
1:08 - 3 very active.
1:11 - 2 appears to be sleeping, rest eating.
1:14 - Doors slam upstairs - no effect on guinea pigs (nor ring of bell).
1:17 - Door slams very hard, 2 turns head, others pay no attention.
1:17+ - Door slams even harder, all guinea pigs tremble slightly.
1:18 - 2 stretches and chews, (others still eating), begins to drink and be active.
1:23 - 1 resting in relaxed position, eyes not visible, 3 playing with overturned glass.
1:25 - 1 makes slight movements.
1:26 - Sudden movement in other cage: all four motionless.
1:28 - 1 still resting, others eating, 3 and 4 very active.
1:29 - 1 scratches ear, turns over, eye almost shut, scratches again.
1:32 - 1 and 3 resting, eyes invisible, breathing pronounced.
1:34 - 2 makes sudden movement and 1 turns head.
1:35 - Sudden sound in vault, all at attention, turn so that one eye is on door.
1:37 - 1, 3 and 4 quiet, eye of 3 half shut.
1:38 - Loud noises do not disturb 3, eyes same.

1:45 - Given carrots, all eating.
2:00 - All eating.
2:07 - 2 and 4 resting.
2:10 - All quiet, 3 eyes partly closed, 4 eyes not visible.
2:15 - 1 active.
2:20 - 1 and 2 active, 3 and 4 resting.
2:30 - All quiet.
2:40 - All resting, eyes visible.
2:50 - 1 and 4 quiet, 2 and 3 eating.
3:00 - All eating.
3:10 - Dropped card, frightened.
3:20 - All quiet, apparently aware of my presence.
3:25 - Went into room and all began to call out and run about.
3:30 - 2 and 3 quiet, rest active, quietly eating.
3:40 - 2 and 3 quiet, rest active, quietly eating.
3:50 - 3 quiet, rest active, quietly eating.
4:00 - 3 quiet, rest active, quietly eating, little running about.
4:05 - All eating.
4:10 - All eating.
4:20 - All eating, 1 keeps same position.
4:22 - 3 and 4 resting, eyes half open.
4:26 - Door slams.
4:28 - 3 and 4 start at movement of 2, 2 quiets down, at rest eye open.
4:30 - 1 still eating, 2 and 3 at rest, eyes two-thirds open, 4 at rest, eyes not fully open (hardly visible).
4:31 - 4 makes sudden start and looks at self in mirror, remains alert.
4:35 - 1, 2 and 3 at rest, eyes open, 4 watches hole.
4:40 - 1, 2 and 3 at rest, eyes open, 4 watches hole.
4:45 - 1, 2 and 3 at rest, eyes open, (make occasional movements) 4 eating.
4:50 - 1 at rest, eyes partly shut; 2 at rest eyes open; 3 at rest, eyes one half open (almost falls over, rights itself suddently), 4 eating.
4:52 - 1 alert, eating.
4:55 - 1, 2, 4 eating, 3 at rest, eyes half closed.
4:57 - 3 begins to eat.
5:00 - All eating, entered room to look at drum, scurrying on part of guinea pigs.
5:05 - Fright over, all four resume eating.
5:10 - All eating.
5:11 - Noise - all alert.
5:12 - 1, 2 and 4 alert, 3 at rest, eyes open.
5:20 - 1 eating; 2 and 3 at rest (2 begins to eat); 4 alert.
5:25 - 1, 2 and 3 eating; 4 alert, motionless.
5:30 - All eating.
5:33 - 1, 2 and 4 eating, 3 at rest, eyes half shut (pulse very noticeable)

5:37 - Door slams.
5:40 - 1, 2 and 4 eating; 3 at rest, eyes half shut.
5:45 - 1, 2 and 4 eating; 3 at rest, eyes half shut.
5:46 - Loud noise, walking above.
5:50 - 1 and 2 eating; 3 at rest as before; 4 at rest, eyes wide open.
5:53 - 2 eating, 1, 3 and 4 at rest.
5:57 - 3 makes restless movements, begins to eat.
6:00 - 2 and 3 eating, 1 and 4 at rest, eyes wide open.
6:05 - 1, 2 and 3 crying out, 4 at rest, 1 darts about.
6:06 - All eating.
6:10 - All eating, 3 very lively again.
6:15 - All eating.
6:20 - Entered room to fix timer.
6:30 - 2 resting, others eating.
6:35 - 3 and 4 eating and moving about; 1 quietly eating; 2 head down, resting and watching hole.
6:45 - 3 and 4 eating and moving about; 1 quietly eating; 2 head down, resting and watching hole.
6:50 - 1 and 4 eating; 2 and 3 resting; eyes of 3 not visible.
6:55 - 1 and 4 eating, 4 very active; 2 and 3 resting; rate breathing of 2 - 81 per minute.
7:00 - 1 and 4 eating, 4 very active; 2 and 3 resting. Resting pig does not stay quiet for more than 2 or 3 minutes at a time.
7:05 - 3 resting; 1, 2 and 4 active.
7:10 - All very active.
7:15 - All began to call each other.
7:20 - All very active.
7:25 - All eating, but less active.
7:30 - 1, 2 and 4 eating; 3 quiet, respiration 84 per minute, eyes open wide. Respiration when resting deeper and more rapid.
7:40 - 3 resting, 1, 2 and 4 eating.
7:45 - 1 very active; 2 and 4 eating; 3 resting, eyes half closed.
7:53 - All quiet; 2 curled up; 3 and 4 eyes half closed; 3 rate of breathing 84 per minute.
8:00 - Same (occasional scratchings, etc.)
8:05 - Same, 2 still curled up, eye open, stretched once.
8:10 - Same, 2, 3 and 4 twitch, 3 eyes visibly open.
8:14 - 3 eating, 2 scratching, 1 and 4 motionless.
8:20 - 1, 3 and 4 eating, 2 still curled up, eyes open.
8:25 - Same.
8:26 - 2 begins to eat straw nearby.
8:30 - 3 and 4 actively eating; 1 and 2 at rest, eyes open.
8:45 - Same, 2 eats straw nearby.
8:50 - All eating, 4 more active.
8:55 - All eating, 2 more active.
9:00 - All eating quietly (bothered by fleas).

9:05 - Same, 4 chewing, at rest.
9:06 - 1, 2 and 3 eating quietly; 4 at rest, eyes half closed.
9:10 - Same.
9:15 - 1, 2 and 3 eating actively ; 4 at rest, chewing, eyes half closed.
9:20 - 2, 3 and 4 eating quietly; 1 at rest, eyes half closed.
9:25 - Experimenter changed paper in drum.
9:30 - 1, 3 and 4 active; 2 sitting quietly.
9:35 - No signs of rest, all eating, scratching, performing toilet, with little jumps.
9:40 - All eating quietly.
9:45 - 1, 2 and 3 chewing vigorously, eyes open; 4 quiet, hunched up like a rabbit.
9:50 - All but 4 still eating.
9:55 - All but 3 are chewing, but move little.
10:00 - 3 and 4 sitting quiet; 1 and 2 watching hole.
10:05 - Noise upstairs, all pigs sitting quiet.
10:15 - 3 and 4 resting, eyes partly closed; 1 and 2 quiet, eyes wide open watching hole.
10:20 - 3 and 4 have eyes partly closed.
10:30 - 3 and 4 quiet, eyes partly closed; 1 resting, eyes on hole, 2 eating.
10:45 - 3 and 4 very quiet, partly open eyes; 1 and 2 sitting quiet with eyes on hole.
10:50 - 1 and 4 quiet; 2 and 3 quietly eating.
10:55 - 1, 3 and 4 sitting, chewing; 2 quietly lying down.
11:00 - 3 and 4 eyes half closed, 1 and 2 quiet, eyes wide open.
11:05 - 1 and 2 moving around eating; 3 quietly eating; 4 resting eyes partly closed; 4 very restless, moves every few seconds.
11:10 - 1 and 2 eating; 3 and 4 quiet, 3 nibbling straw.
11:20 - 1 eating; 2 sitting quietly; 3 and 4 very quiet resting, 3 nibbling straw every little while.
11:25 - 1 sitting quiet; 2, 3 and 4 eating.
11:30 - 1 and 3 quiet; 2 and 4 eating.
11:35 - 1 started to eat.
11:40 - Dropped top of pen and frightened guinea pigs.
11:55 - Not a pig moved for 15 minutes, then one started to eat and rest remained at attention.
12:00 - 3 eating; 1, 2 and 4 sitting quiet.
12:10 - All four alert and eating, but not running about.
12:15 - Same.
12:20 - 3 has been sitting with half closed eyes for several minutes, 1, 2 and 4 as above.
12:25 - 3 was startled once by a sudden movement of 4, then settled back to half eye closed condition as above; 4 sitting like 3; 1 and 2 feeding.
12:30 - 3 wide awake; 1 and 2 as above; 4 quiet.

12:35 - 4 wiped nose vigorously; 1 chewing edge of drinking cup.
12:40 - 3 and 3 scratch and bite at their bodies without opening eyes completely.
12:45 - 2 resting quietly; 1 continues attack on water cup.
12:50 - 2 and 4 quiet, eyes half closed; 1 and 3 active, scratching, washing face, etc.
12:55 - 3 has shifted position; 2 sits with eyes half closed; 4 has scarcely changed position since I came in; 1 most active.
1:00 - All quiet.
1:05 - All quiet. - (dropped card and all guinea pigs jumped)
1:10 - 3 has shifted position, eyes are open; 4 continues to have half closed eyes.
1:15 - All quiet, but not sleeping.
1:20 - Same.
1:25 - 1 has not had eyes half closed at all; all quiet but 4 - feeding.
1:30 - 4 feeding, others quiet.
1:35 - All alert, 3 and 4 feeding.
1:40 - 1 and 2 at rest, eyes half closed; 3 and 4 feeding.
1:45 - 1 has eyes wide open watching hole; 2, 3 and 4 same as above; 2 chews where he lies at rest, eyes open.
1:50 - All have been eating quietly.
1:55 - All eating, very wide awake; 4 most continuously active.
2:00 - Same; 4 takes numerous drinks.
2:05 - Same; 4 takes another drink. 1 and 2 start suddenly, no cause; 1, 2 and 4 still eating; 3 at rest, eyes wide open.
2:10 - 2 reached up side of cage; startled others.
2:15 - 2 and 3 at rest; 1 and 4 eating, 4 more active.
2:20 - 2 curled up, 3 at rest; both show sudden changes of position, scratch, etc. 2 stretches out more, eyes invisible; 4 at rest, eyes half shut, 1 eating.
2:25 - 2, 3 and 4 at rest; 1 eating.
2:30 - 3 chews on nearby straw; eyes of 2 invisible; of 4 half closed.
2:35 - 1, 2 and 3 eating quietly; 4 at rest, head on one side, eyes half closed.
2:40 - 1, 2 and 3 eating quietly; 4 at rest; noise which startles 1, 2 and 3 does not affect 4.

2:45 - 1 still eating; 2, 3 and 4 at rest; 4 makes continual re-settling movements, yawns, stretches, etc. Door slams, all at attention, resume former pose quickly.
2:50 - 1 still eating; 2, 3 and 4 at rest, eyes all open.
2:55 - 1, 2 and 3 at rest; 4 qide awake and active, eating.
3:00 - All watching hole.
3:05 - 1, 3 and 4 quiet, eyes on hole; 2 nibbling.
3:10 - 1, 2 and 3 quiet; 4 eating.
3:15 - All awake, eating, not very active.

3:20 - All eating vigorously.
3:25 - 1 quiet; 2, 3 and 4 eating.
3:30 - Put on coat and disturbed guinea pigs, all watching hole.
3:35 - 1 and 3 quiet; 2 and 4 eating.
3:40 - All eating.
3:45 - 4 running and jumping; 2 and 3 eating; 1 eating quietly.
3:50 - 1 quiet; 2, 3 and 4 active, eating.
3:52 - 2 jumping around and making noise.
3:55 - 1 and 4 resting quietly; 2 and 3 eating.
4:00 - 1 and 4 quiet; 2 and 3 eating.
4:05 - 1 and 3 quiet, 4 half closed eyes; 2 eating vigorously.
4:10 - 1 and 2 eating; 3 and 4 quiet.
4:15 - 1 and 2 eating; 3 and 4 quiet.
4:20 - All quiet; 4 has half closed eyes, nose down, eyes now reduced to tiny slits.
4:25 - All quiet; 1 in position of repose, eyes a little shut; 4 eyes half shut.
4:30 - All quiet; all open eyes except 2, eyes half closed and very still.
4:35 - 1 and 2 quiet; 3 and 4 eating quietly; 1 has look of repose and lies down more completely.
4:40 - All quiet; 1 and 2 not eating; 2 keeps keeling over, catches himself, sits up again; eyes half closed for a moment only; 3 and 4 chew busily.
4:45 - 1 up and about again; 2 settled down, quiet, only ears twitch, eyes - slits; 4 same as 2; 3 chewing.
4:50 - 4 picture of repose; eyes merest slits; 1, 2 and 3 chewing again.
4:55 - Eyes of 4 I should call closed, can see no reflection from them; 1, 2 and 3 sitting quiet, 3 eating, 4 alternating between repose and chewing with half open eyes.
5:00 - 2 is lying on his side, quiet except for twitching ears, eyes half closed, jerks up again, lay there about two minutes; 1 and 3 move about; 4 continues the quietest of the lot, is it because he is furthest from observer?
5:05 - 1, 2 and 3 mildly active; 4 is perfectly still.
5:10 - 1, and 2 move about quietly, eating; 3 sitting motionless, eyes half closed; 4 chews; 1 scratches, eyes half closed.
5:15 - 1 active; 2 eating busily; 3 very still, eyes barely visible; 4 quietly chewing as above.
5:20 - 1 and 2 eating; 3 and 4 sitting hunched up, still except for periodic dleas; 3 comes to and eats a bit; 4 remains quiet, eyes almost closed.
5:25 - All eating; 4 stretching and moving about.
5:30 - All eating quietly, wide eyed.
5:35 - Whispered conversation, all sitting quiet.

5:40 - All sitting quiet, 3 with his nose down, eyes almost closed.
5:45 - All sitting quiet, no eating, eyes open.
5:50 - Same.
5:55 - 1 and 3 perfectly quiet; 2 and 4 fidgety.
6:00 - 1 lying with head down, eyes half shut (up again in one minute); 3 continues very still, eyes half closed; 2 and 4 sitting quiet but alert.
6:05 - 3 chewing, others quiet but awake.
6:10 - 3 and 4 chewing vigorously, wide awake; 1 and 2 quiet.
6:15 - 1 feeding; 2, 3 and 4 spasmodically washing face and paws. (changed chair with slight noise)
6:20 - All quietly sitting in corners, awake but not active. Note that each animal sits in corner nearest oat supply most of the time.
6:25 - All feeding.
6:30 - All feeding and wide awake.
6:35 - 2 gets drink; 3 sneezes violently; 1 and 4 feeding quietly.
6:40 - 1 and 2 rush about cage periodically; 3 and 4 feeding quietly.
6:45 - 3 startled by unknown cause; 1 and 2 respond instantly; 4 chews bed tranquilly.
6:50 - All quiet.
6:55 - All quiet, but awake.
7:00 - 4 sits with half closed eyes; 3 washes face; 1 drowsy; 2 biting hind leg.
7:05 - 4 sits with half closed eyes; 1 and 2 eat; 3 rests, eyes open.
7:10 - 1 and 2 eat quietly, 3 and 4 at rest; 4 begins to chew and then scratch leg.
7:15 - 1 and 2 eat quietly; 3 and 4 at rest.
7:20 - 1 sits still chewing; 2, 3 and 4 at rest.
7:30 - 1 eating;, 2, 3 and 4 at rest; 2 curled up; 4 makes stretching movements, 3 and 4 begin to nibble.
7:35 - 1, 2, 3 and 4 eating; 3 at rest, eyes open.
7:45 - 1 has been biting at fleas vigorously, settles down with 2 to rest; 4 feeding; 3 washing himself.
7:50 - 1 at rest; 2, 3 and 4 feeding; 4 most active.
7:55 - 1 at rest, eyes half closed; 3 at rest; 2 and 4 feeding; 3 head falls over, jerked back.
8:00 - Same.
8:05 - 1 and 3 at rest; 2 and 4 feeding.
8:10 - Same; 2 very active.
8:15 - 3 at rest; 1 rushes around; 2 and 4 quietly feeding.
8:20 - All chewing.
8:25 - All eating vigorously.
8:30 - Same and watching hole.
8:35 - All eating vigorously.
8:40 - Same and cleaning themselves.

8:45 - Same.
8:50 - All running about, leaping and jumping, calling out.
8:55 - Same.
9:00 - Same.
9:05 - All eating.
9:10 - 1 and 3 eating; 2 and 4 quiet.
9:15 - 1 eating; 2, 3 and 4 quiet.
9:20 - 1 and 2 eating; 3 and 4 quiet eyes open.
9:30 - 1 eating; 2 quiet, eyes open; 3 and 4 eyes partly closed.
9:35 - All quiet, 3 and 4 more relaxed than 1 and 2.
9:40 - All quiet, relaxed.
9:45 - 1 and 3 at rest; 2 and 4 eating.
9:50 - Same.
9:55 - 4 eating; 1, 2 and 3 resting.
10:00 - Alert, (whispering); 4 eating.
10:05 - 1, 2 and 3 quiet relaxed, 4 eating.
10:10 - Same.
10:15 - 2 and 3 quiet, relaxed; 4 eating; 1 moving, yawning. (whispering).
10:20 - 2 and 3 quiet; 2 scratched twice; 4 quiet but alert; 1 active.
10:25 - 2, 3 and 4 quiet and relaxed; 4 has eyes almost closed; 2 alert.
10:30 - 1 eating; 2, 3 and 4 quiet and relaxed.
10:35 - 1 and 2 eating and scratching; 3 and 4 quiet and relaxed.
10:40 - 1, 2 and 3 eating; 1 and 2 very active, talking; 4 quiet and relaxed.
10:45 - All eating.
10:50 - All eating and talking.
10:55 - Same.
11:00 - All eating vigorously.
11:05 - Same.
11:10 - Same; 1 and 2 jumping about.
11:15 - All eating more quietly.
11:20 - 1 and 4 eating; 2 and 3 quiet.
11:25 - 1 eating; 2, 3 and 4 quiet.
11:30 - 1 eating; 2, 3 and 4 quiet.

Table 1

Weight in grams

Date	Guinea pig A	Guinea pig B	Guinea pig C	Guinea pig D	Guinea pig E	Guinea pig F
Oct. 14	222	236	182	261	255	316
" 17	228	254	179	278	260	319.5
" 24	251	271	207	299	286	330.5
" 28	267	291	222	321.5	306	339
Nov. 2	288	291	246	331.5	299	335
" 9		309	247		313	

Growth of a group of guinea pigs kept in the vault.

Table 2

Date	Guinea pig A	Guinea pig B	Guinea pig C	Guinea pig D	Guinea pig E	Guinea pig F
(Weights) in grams	222	236	182	261	255	316
Oct. 18	20.5	19.6	20.8	22.8	23.0	22.3
" 19	22.5	19.2	18.8	20.8	18.2	17.5
" 20	21.8	20.9	21.5	23.0	22.5	20.0
" 21	20.6	20.2	22.1	21.4	20.9	18.3
" 22	20.3	18.5		19.7	19.2	20.8
" 23	22.4	10.6	22.0	22.9	20.7	21.8
" 24	20.6	19.8		21.2	21.9	21.7
Average	21.24	19.69	21.04	21.73	20.81	20.34

Average Activity for 23 hours 20.8 hours

Average Activity for 24 hours 21.6 hours

The amount of activity in hours of six guinea pigs in the dark for seven days.

Table 3

Date	Guinea pig A	Guinea pig B	Guinea pig C	Guinea pig D	Guinea pig E	Guinea pig F
Nov. 29	18.2	23.4	22.4	23.1	22.2	18.3
" 30	19.7	21.1	20.0	20.1	17.6	16.2
Dec. 1	22.7	20.0	21.1	20.8	19.6	18.7
" 2	18.6	16.4	20.2	21.0	19.8	16.0
" 3	20.8	21.8	23.4		22.2	23.0
Average	20.0	20.54	21.4	21.25	20.3	18.44
Average Activity for 24 hours						20.38

The amount of activity in hours of six guinea pigs in the dark for five days. The same guinea pigs that were used in table 2 - only six weeks later.

Table 4

Date	Guinea pig A	Guinea pig B	Guinea pig C	Guinea pig D	Guinea pig E	Guinea pig F
(Weights) in grams	251	271	207	299	286	330.5
Oct. 26	21.9	18.9	19.2	20.0	16.9	18.9
" 27	20.3	19.9	19.0	22.6	22.0	20.9
" 28	20.7	19.9	19.1	19.9	20.0	21.6
" 29	21.9	22.2	21.2	21.9	21.7	21.2
" 30*	10.7	10.1	10.6	10.8	11.1	11.4
" 31	22.6	19.8	20.6	18.9	19.9	18.6
Nov. 1	21.8	19.0	17.3	18.0	16.1	15.6
Averages	21.53	19.95	19.40	20.21	19.43	19.46

Average Activity for 23 hours 19.83 hours

Average Activity for 24 hours 20.64 hours

The amount of activity in hours of six guinea pigs in the light for seven days.

* On a run of 12 hours.

Table 5

Date	Guinea pig 1	Guinea pig 2
Dec. 11	20.0 hours	
" 12	21.8 "	
" 14		19.8 hours
" 15		20.6 "
Average (alone)		20.55 hours

Date	Guinea pig A	Guinea pig B
First day	21.1 hours	20.9 hours
Second day	21.4 "	21.5 "
Average (two together)		21.25 hours
Average (six together)		20.38 hours

Activity of a guinea pig alone compared with the activity of several guinea pigs together.

Table 6

Date	Guinea pig 1	Guinea pig 2	Guinea pig 3	Guinea pig 4	
Feb. 15	21.6		22.8	22.9	
" 16	20.5	20.5	18.3	21.0	
" 17	20.0	21.5	21.7	22.5	
" 18	18.0	17.5	21.5	20.3	
" 19	22.7	23.7	23.9	22.1	
Averages	20.56	20.8	21.64	21.76	21.19

Showing the activity of four guinea pigs three months old.

Table 7

Date	Guinea pig A	Guinea pig B	Guinea pig C	Guinea pig D	
Feb. 23	23.5	23.0	23.6		
" 24	22.0	23.9	19.6	20.9	
" 26	21.7			19.1	
" 27	22.1		22.3	23.4	
" 28	21.0	19.0		17.0	
Mar. 1	19.7	22.7	17.6		
Averages	21.66	22.15	20.8	20.1	21.18

Showing the activity of four guinea pigs nine months old.

Table 8

Date	Guinea pig A	Guinea pig B	Guinea pig C	Guinea pig D	Guinea pig E	Guinea pig F
Nov. 3	20.6	20.0	20.1	18.9	19.3	13.0
" 4	21.5	21.0	20.5	21.4	22.8	21.4
" 5	22.1	21.3	20.7	21.1	22.6	22.4
" 6	12.0 *	10.8	11.0	11.4	11.4	12.0
" 7	22.4	20.9	22.4	22.6	22.6	23.0
" 8	22.4	21.3	22.0	21.8	22.4	23.0
" 9	22.7	21.8	22.3	22.2	22.4	22.8
Averages	21.95	21.05	21.05	21.33	22.0	20.93
Average for 23 hours		21.5 hours			21.42 hours	
Average for 24 hours		22.3 hours			22.2 hours	

* 12 hours only were measured.

Amount of activity in hours of three guinea pigs fed for an hour a day for seven days compared with three controls having food in the cage all of the time.

Table 9

	Food one hour			Controls		
Date	Guinea pig A 222 gms.	Guinea pig D 333 gms.	Guinea pig F 335 gms.	Guinea pig B 291 gms.	Guinea pig C 246 gms.	Guinea pig E 299 gms.
Nov. 3	-14.2%	-2.9%	0%	1.9%	2.6%	1.8%
" 4	- 1.0%	.4%	-.6%	1.4%	1.4%	-1.0%
" 5	-1.0%	-1.6%	-2.0%	2.2%	-1.6%	2.0%
" 6	-2.9%	-2.7%	.1%	-2.0%	1.4%	-3.8%
" 7	0%	3.5%	-1.8%	.2%	-1.8%	1.8%
" 8	-1.4%	.6%	.7%	.2%	.7%	.5%
" 9	0%	-1.6%	-1.5%	2.4%	-2.4%	3.2%
Total % loss or gain	-20.5%	-4.9%	-5.1%	6.3%	.4%	4.5%

Percentage loss in weight per day of three guinea pigs fed for one hour a day for seven days. Also percentage gain in weight of three controls. See Figure I.

Table 10

	Guinea pig 1	Guinea pig 2	Guinea pig 3	Guinea pig 4	Guinea pig 5	Guinea pig 6
First day	19.4	16.5	19.3	16.4	12.6	17.7 hours
Second day	19.9	18.8	17.9	18.7	16.2	21.4 hours
Third day	18.0	16.6	17.4	7.8	7.1	7.6 hours

Amount of activity in hours of three guinea pigs without food for three days and their controls.

Table 11

	Guinea pig 4		Guinea pig 5		Guinea pig 6	
	Weight grams	% loss	Weight grams	% loss	Weight grams	% loss
Dec. 6	350.5		305.0		305.5	
" 7	349	- 1.8%	299	- 1.9%	298.5	- 2.2%
" 8	215.5	- 9.4%	275	- 8.0%	267	- 10.7%
" 9	296.	- 6.0%	253.5	- 7.8%	246.	- 6.8%
" 14	305.5	+ 2.5%	315.5	+ 20.3%	305.	+ 19.3%

Loss in weight of three guinea pigs without food for three days and their recovery. See Figure II.

Table 12

Guinea pig	Weight grams	No. of revolutions	Distance miles	Time hours	Loss in weight
E	245	789	.81	3	3
A	249	793	.82	2.25	6
D	254	757	.77	3.41	5
C	264	709	.73	3.16	6
B	309	1636	1.67	4.75	6
F	314	1951	1.90	5.83	5

Data concerning six guinea pigs fatigued to the point of extreme exhaustion.

Table 13

Date	Temperature 12 noon	Guinea pig A	Guinea pig B	Guinea pig C	Average Activity
April 4	65'	17.3	20.6	19.1	19.0
" 5	65'	21.7	20.4	21.8	21.3
" 6	65'	21.2	23.4	21.0	21.8
" 7	65'	21.2	22.8	20.0	21.3
" 8	79'	17.0	20.0	20.3	19.1
" 9	83'	15.8	17.3	16.3	16.4
" 10	85'	10.0	13.0	13.4	12.1
" 11	85'	12.7	13.3	11.6	12.5
" 12	79'	15.1	15.3	14.9	15.1
" 13	84'	12.0	11.3	7.7	10.3
" 14	86'	10.8	9.0	7.7	9.1
" 15	87'	10.4	12.1	10.7	11.1
" 16	87'	8.3	7.5	8.1	7.9

Showing the influence of temperature upon the activity of the guinea pig.

Table 14

Fatigued for one hour

Guinea pig	Activity 1st hour	Activity 1st hour fatigued	% diff.	Activity 2nd hour	Activity 2nd hour fatigued	% diff.
No. 45	719	634	-11.8	696	667	-4.1
Control No. 40	481	273	-43.2	286	252	-11.8
No. 42	774	806	+ 4.2	588	746	+27.0
Control No. 47	1425	1278	-10.3	1210	666	-44.9
No. 46	1334	1089	+18.3	1189	1120	- 5.9
Control No. 40	193	235	+21.7	172	288	+67.4
No. 43	1690	1307	-22.6	1113	1221	+ 9.7
Control No. 44	1346	1372	+ 2.7	1201	1168	+ 2.7
Fatigued for one and one half hours						
No. 45	898	1336	+48.7	797	990	+24.2
Control No. 44	125	224	+79.2	128	286	+45.3
No. 42	961	972	+ 1.1	726	227	-68.7
Control No. 47	1533	942	-38.7	1331	1298	- 3.3
No. 46	998	1286	+23.9	773	993	+26.0
Control No. 44	93	241	+159.0	77	223	+189.0
No. 43	1278	438	-65.7	1030	613	-40.4
Control No. 47	1148	943	-18.0	905	1216	+34.3

Fatigued for two hours

Guinea pig	1st hour	1st hour fatigued	% diff.	2nd hour	2nd hour fatigued	% diff.
No. 45	656	731	+11.4	821	749	-8.7
Control No. 44	696	635	- 8.8	689	703	+2.0
No. 42	458	128	-72.0	288	126	-56.2
Control No. 47	422	326	-22.7	724	782	+8.0
No. 46	974	784	-19.5	725	517	-28.6
Control No. 44	698	754	+ 8.0	749	423	-43.5
No. 43	299	211	-29.5	398	220	-44.9
Control No. 47	550	675	+22.7	253	571	+125.6

Fatigued for two and one half hours

No. 45	817	597	-39.1	588	312	-46.8
Control No. 44	776	703	- 9.5	455	412	- 9.4
No. 42	378	644	+70.3	276	409	+48.1
Control No. 47	423	245	-42.0	360	241	-33.0
No. 46	776	524	-32.4	812	375	-52.8
Control No. 44	434	306	-29.4	148	116	-21.8
No. 43	506	702	+38.7	545	665	+22.0
Control No. 47	109	220	+101.8	225	210	-6.6

Fatigued for three hours

Guinea pig	1st hour	1st hour fatigued	% diff.	2nd hour	2nd hour fatigued	% diff.
No. 45	584	652	+11.6	385	684	+77.6
Control No. 44	250	390	+56.0	268	266	- .7
* No. 42	563	88	-84.2	571	93	-83.7
Control No. 47	362	290	-19.8	156	364	+133.0
No. 46	750	1252	+66.8	711	816	+14.7
Control No. 44	296	718	+159.0	382	689	+80.3
No. 43	230	341	+48.2	210	224	+6.6
Control No. 47	362	265	-26.8	253	275	+8.6

* Guinea pig 42 did not look well before he was fatigued. He died in a few days.

Showing the number of movements of guinea pigs before and after being fatigued in a revolving drum for increasing increments of time, with percentage difference.

Table 15

Guinea Pig	Fatigued 1 hour grams	Fatigued 11 1/2 hours grams	Fatigued 2 hours grams	Fatigued 21 1/2 hours grams	Fatigued 3 hours grams
No. 45 (306)	3.5	4.5	4.5	4.5	7.0
No. 42 (330)	2.0	2.5	6.0	4.0	15.0
No. 43 (245)	0	1.0	3.0	4.0	3.0
No. 46 (268)	.5	.5	5.0	6.0	8.0
Average loss	1.5	2.1	4.6	4.6	8.2

Loss of weight of four guinea pigs fatigued on successive days for increasing periods of time.

Table 16

Date	Guinea pig 1	Guinea pig 2	Guinea pig 3	Guinea pig 4
Nov. 19 Obs. Exp.	14.5	15.4	13.8	15.9
Nov. 20	15.6	16.8	16.0	18.1
" 21	19.8	22.7	18.9	19.2
" 22	17.0	20.7	18.0	19.8

The amount of activity in hours of the four guinea pigs in the Observation Experiment and the three succeeding days.

Table 17

Date	Pig A hours	Pig B hours	Rat A hours	Rat B hours
Nov. 10	23.1	23.3	13.8	9.2
" 11	20.3	21.9	17.2	10.5
" 12	22.3	23.4	12.1	8.0
" 13	21.0	22.6	11.6	9.5
Averages	21.7	22.8	13.7	9.3
"	22.28		11.5	

The amount of activity of two guinea pigs and two rats in the vault together for four days. See Figure V.

Table 18

Date	Pig A hours	Pig B hours	Rat A hours	Rat B hours
Nov. 10	.9	.7	10.2	14.8
" 11	3.7	2.1	6.8	13.5
" 12	1.7	.6	11.9	16.0
" 13	3.0	1.4	12.4	14.5
Averages	2.3	1.2	10.3	14.7
		1.75		12.5

The amount of rest of two guinea pigs and two rats in the vault together for four days. See Figure VI.

Table 19

	Pig A	Pig B	Rat A	Rat B
Total Activity hours	21.1	20.9	12.6	10.9
Activity 6 a.m. - 6 p.m.	10.6	10.6	5.0	3.4
Activity 6 p.m. - 6 a.m.	10.5	10.6	7.6	7.5
Total Rest	2.9	3.1	11.4	13.1
Rest 6 a.m. - 6 p.m.	1.4	1.4	7.0	8.6
Rest 6 p.m. - 6 a.m.	1.5	1.7	4.4	4.5
Second day				
Total Activity	21.4	21.5	9.3	6.7
Activity 6 a.m. - 6 p.m.	11.2	10.9	3.5	2.5
Activity 6 p.m. - 6 a.m.	10.2	10.6	5.8	4.2
Total rest	2.6	2.5	14.7	17.3
Rest 6 a.m. - 6 p.m.	.8	1.1	8.5	9.5
Rest 6 p.m. - 6 a.m.	1.8	1.4	6.2	7.8
Average Activity	21.25		9.87	
Average Activity 6 a.m. - 6 p.m.	10.8		3.87	
Average Activity 6 p.m. - 6 a.m.	10.4		6.27	
Average Rest	2.77		14.1	
Average Rest 6 a.m. - 6 p.m.	1.17		8.4	
Average Rest 6 p.m. - 6 a.m.	1.6		5.7	

The amount of activity and of rest of two guinea pigs and two rats in the vault alone for two days.

Plate 1.

Activity Recording Apparatus.

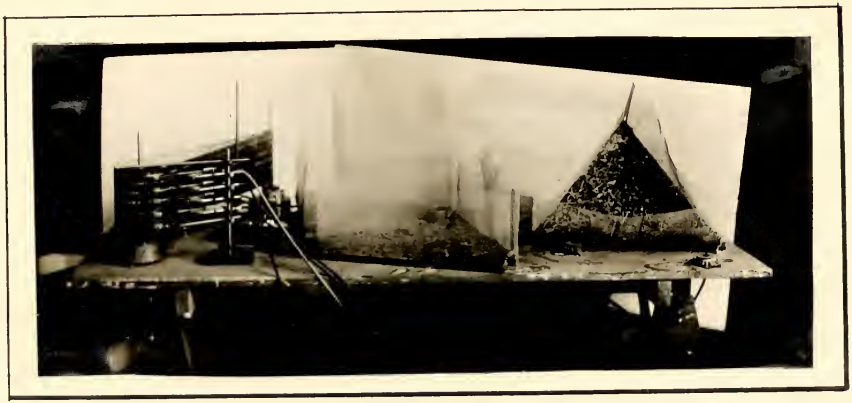


Plate 2 A.

Revolving cage used in fatiguing the guinea pig.

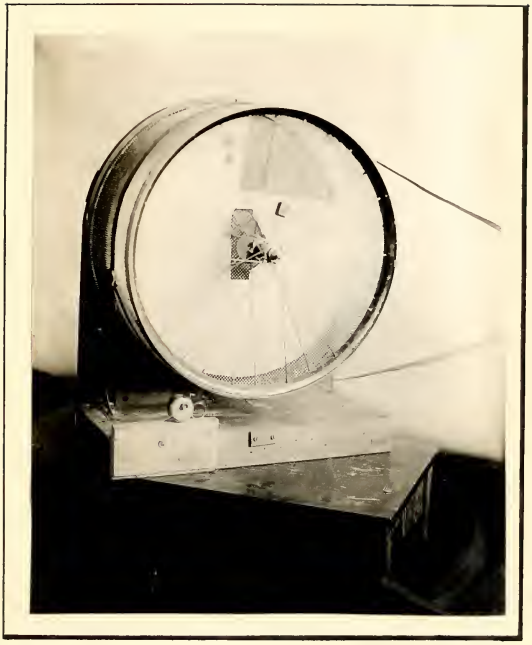


Plate 2 B.

Map Measurer.

INCHES

Plate 3.

Showing the "continuous" activity periods of over ten minutes of three different guinea pigs.

I. The activity of the same guinea pig on three different days.

II. The activity of three different guinea pigs on the same day in the dark.

III. The activity of three different guinea pigs on the same day in the light.

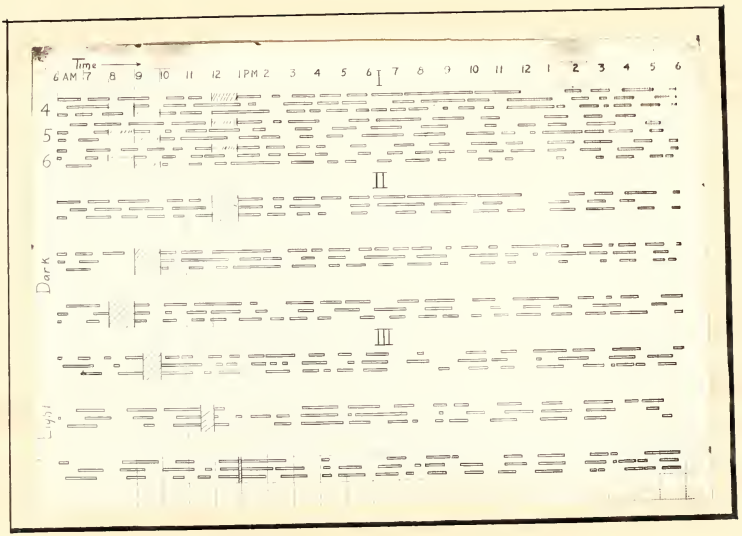

Time
6 AM 7 8 9 10 11 12 1PM 2 3 4 5 6 7 8 9 10 11 12 1 2 3 4 5 6
I
4
5
6
II
Dark
III
Light

Plate 4.

An original record showing the activity of six guinea pigs in the dark.

FOLD OUT

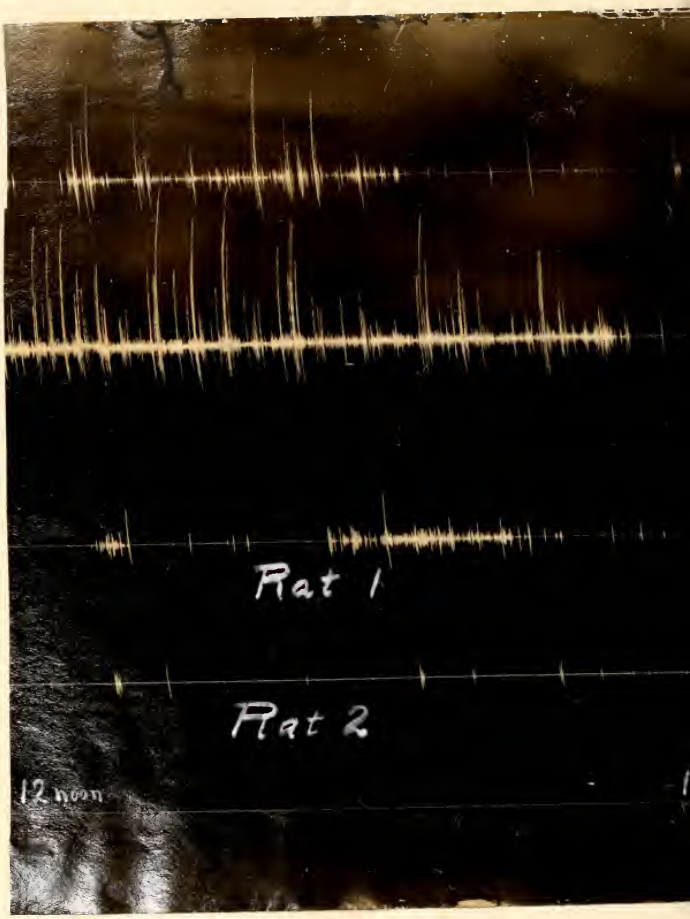
Plate 5.

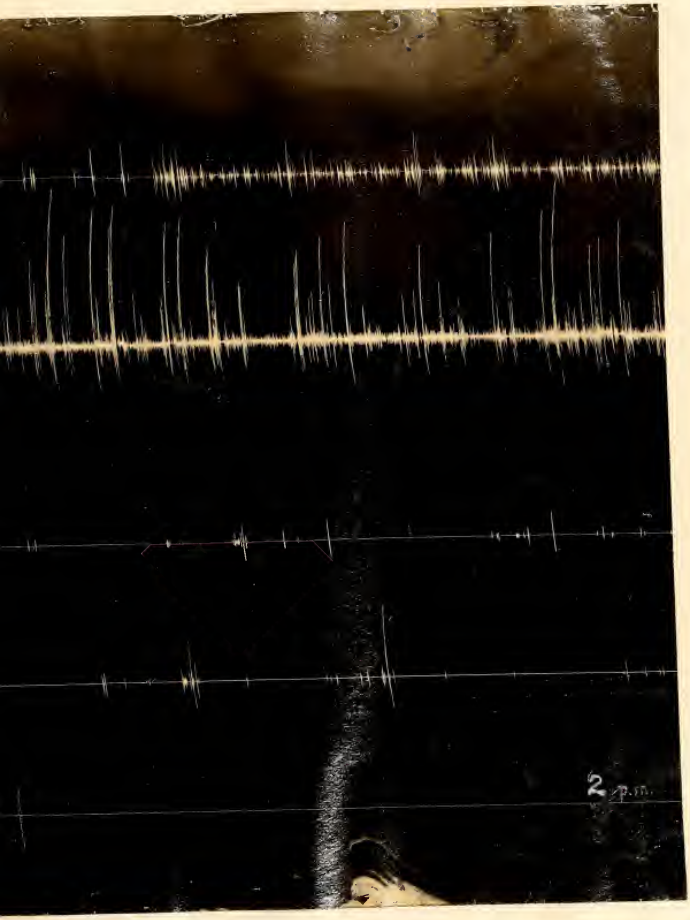
An original record showing the activity of six guinea pigs in the light.

FOLD OUT

Plate 6.

Original records showing the activity of two rats and two guinea pigs from twelve to two o'clock during the day and from twelve to two o'clock at night.


Rat 1
Rat 2
12 noon


2 p.m.

FOLD OUT

Plate 7.

Original records showing the activity of two guinea pigs at a temperature of 65° F. (upper record) and at a temperature of 85° F. (lower record).

FOLD OUT

VITA

Edith Evelyn Nicholls was born in Cleveland, Ohio, September 29, 1895. She was educated in New York City and spent the year 1908-1909 in England and Germany. She prepared for college at Hillside School and Capen School and received the degree of Bachelor of Arts from Smith College in June, 1919. In September, 1919, she entered the Johns Hopkins School of Hygiene and Public Health.

She is joint author of the following paper:

"The Relation between Fatigue and the Susceptibility of Guinea Pigs to Type I Pneumococcus". E. E. Nicholls and R. A. Spaeth, American Journal of Hygiene, September, 1922.